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THE AMERICAN
METEOROLOGICAL JOURNAL.

VOL. VI. ANN ARBOR, APRIL, 1890. NO. 12.

ORIGINAL ARTICLES.

TROMBES AND TORNADOES.

BY H. FAYE,
Membre de l'Institut, President du Bureau des Longitudes, etc.

Starting from Redfield's Laws which may be regarded as the generalized expression of facts scientifically studied, we have concluded that an intimate analogy exists between cyclones and the whirls of our water-courses, and we have tried to prove that cyclones are themselves descending whirls with vertical axes engendered in the upper currents of our atmosphere.

The analogy between *trombes* or tornadoes and the whirls of streams and rivers is still more striking, for the first, as well as the second, can be embraced in a *coup d'œil,* and, to the identity of the movements of translation and of gyration, is added the intimate resemblance of form. We may then conclude, by way of analogy, that tornadoes are descending whirls with vertical axes, originating in the upper currents of the atmosphere, situated much lower than the generating currents of cyclones.

But here we encounter a preconceived idea, a prejudice which must be put aside under penalty of allowing doubts to cloud this theory in the minds of many persons. When, seventeen or eighteen years ago, I made known these ideas concerning

storms, meteorologists hastened to respond:—Suppose that there might be the shadow of a doubt as to the ascending movement of air in cyclones; the question would be answered by the statement that *trombes* or tornadoes, veritable cyclones in miniature, transport the water of the ocean or of ponds over which they pass, to the clouds. The air then is ascending, and it consequently ascends in storms.

This assertion of the meteorologists is based upon general assent, and upon the testimony of ocular witnesses, thousands in number. It has served as a basis of accepted theories for a century. We cannot dispense with an examination of this assertion and these theories. In doing this we will support our statements with the most reliable observations—those of the Signal Office. The result of this examination will show that the idea of the aspiration of *trombes* or tornadoes so strongly anchored in the imagination, from the most remote times, is only an illusion, and that tornadoes or *trombes* are, like cyclones, descending whirls, with vertical axes, originating in the upper currents, and following the direction of these currents. This would be a striking confirmation of the conclusions of the preceding article.

CHAP I.—HISTORICAL PART.

Popular ideas, like that regarding the pumping of water by *trombes*, from sea to clouds, and the legend of the *Phantom Ship*, have always some foundation in fact, which the imagination has wrongly interpreted, and upon which is immediately embroidered a multitude of details. A vessel abandoned by its crew may continue to sail at the hazard of winds and currents during entire years, if it is lightly loaded. It does well if there is water everywhere; it floats half dismantled like the American schooner of which Mr. Everett Hayden has traced the peregrinations in the February, 1889, number of the AMERICAN METEOROLOGICAL JOURNAL, from the terrible hurricane of March 11, 1888 to January, 1889, at which time it finally ran aground upon the rocks of the Hebrides. When such a waif is encountered during the night, the imagination, greatly excited, gives it masts, sails, an equipment of spectres, doubtless condemned for

some cruel deed to wander upon the seas: an encounter with it becomes a presage of misfortune or of storm. These tales which have obtained credence for so long a time are no longer current. Captains content themselves with consigning the apparition to their log books in expressing the desire that a government, mindful of the security of navigation, might send out a war-ship in search of the dangerous waif, to complete its destruction.

The idea that *trombes* aspire the water of seas to the clouds is similarly based upon real facts falsely interpreted. The early navigators, in contemplating the strange spectacle of a *trombe* descending before their eyes, from a cloud to the waves which it seemed to penetrate while agitating them violently, asked themselves what this long tube, formed of a light mist, was going after in the sea. Undoubtedly for water to feed the clouds from which it was seen to descend. "That which strengthens this opinion," say Buffon, "is the rains, or rather the torrents which often fall in the vicinity of *trombes*." Nevertheless all observers were not contented with this *näive* affirmation. There were those who wished to verify and see for themselves whether water really ascended in *trombes*. They affirm that they saw it; since then testimony of this kind has multiplied singularly. There must have been a real fact, that is an ascending movement, more or less characteristic, and it remains to be seen whether it was the water of the ocean, or something else which was seen to ascend. The first alternative assumes that what happens in the interior of a *trombe* or a tornado can be seen. This is not true; *trombes* or tornadoes have an opaque cloud-sheath, through which it is as impossible to see as through a cloud. Mr. Finley says, in his valuable little book entitled "Tornadoes," in the article "A Scientific Résumé of Tornado Characteristics." "The tornado cloud is generally impenetrable to vision, and is sometimes dark, like coal smoke, and then again white, like steam." It is not water, then, which so many observers have seen ascending in *trombes*; it must be something belonging to the opaque tube, to the sheath formed of cloud, of particles of condensed vapors, which

alone is visible. The air of the *trombe* is cold, colder than the surrounding atmosphere. Descending through warm, humid strata, it determines all around it a condensation of this humidity and surrounds itself with a cloud sheath. At the same time this column of air descending with a certain velocity, causes in the surrounding air a feeble inverse movement, an eddy, which, little by little, carries upward a part of these misty vesicles. It is thus that a powerful cascade makes the foam ascend from below the whole length of the nappe of water to its source. If this foam, formed of little fine drops of water, was opaque, the spectator seeing it ascend, might believe for an instant that the water was ascending in a cascade.*

It is true that the sheath is not always opaque. It might happen that it is not formed in a part of the tube of the *trombe* or tornado, for when the descending air traverses an atmospheric stratum of which the temperature is too far removed from its dewpoint, the *trombe* will be transparent at that place for a time. It ought to show water ascending in the interior. Nothing is seen there. We owe to the celebrated Captain Cook an observation of this nature. "They (the *trombes*) manifest themselves first, by the violent agitation and elevation of water. An instant after a round column is seen, which is detached from the clouds above, and which appears to descend until it joins the agitated water. I say it appears, because I believe that this descent is not real, but that the agitated water below has already formed the tube, and that in raising itself it is either too small or too thin to be seen at first." There is only one point in this recital to be retained, it is that in a place where the cloud sheath was interrupted, Cook tried, unsuccessfully, to see water ascend. The only thing which was seen to ascend in these *trombes*, according to some of the crew, was a bird. "It rose," says Cook, who heard of it, but did not see it himself, "while turning like the regulator of a turn-spit." It might have been a fish; but how could a bird introduce itself into this ascending *trombe?* It was without doubt, a light flake,

*See the observations of M. Colladon about a Swiss cascade well known to tourists, in the *Comptes rendus* of the Academy of Sciences, session of August 4, 1879.

detached from the exterior fog, which caused this singular impression.

It will be objected that there are other proofs that water ascends in trombes; for example, this fact, several times observed, that if a *trombe* passes over a pond or river, the water level is lowered, and sometimes the bed is left dry. We will discuss these facts further on. Here I wish to show first, how minds, otherwise judicious, beginning with a false idea or a visual impression wrongly interpreted, deduce with some logic, consequences, which in passing from mouth to mouth, end with being accepted as facts.

Imagine a *trombe* of ten meters in diameter below and four hundred meters in height. It will contain, at the least, without counting its upper enlargement, 31,400 tons of water, weighing thirty-one millions of kilogrammes. Observe that no one asks how a tube, formed, not of bronze or steel, but of a simple sheath of mist, which oscillates and bends with a breath of air, could sustain such a weight, but it would without doubt be asked what would become of the water should the *trombe* break. This water falling suddenly from a great height, would fall like a building into the waves; if an unfortunate vessel were below, it would be crushed and submerged. What can be done in such a case? In general the *trombe* appears in muggy, warm weather, in a perfect calm. It progresses however, while the vessel is not in a condition from lack of wind to avoid it. There is but one answer: if the *trombe* approaches the vessel break it with cannon shots before being reached by it. Cook regretted not to have profited by this resource; he had a loaded cannon but did not think of it, absorbed as he was in the contemplation of the terrifying spectacle.

What becomes of this water pumped from the ocean? Evidently the *trombe* carries it to the cloud, which enlarges visibly and becomes darker. After some time the cloud too heavily charged relieves itself of the water by a down-pour. A little of this water which came from the ocean was saved; it was tasted and found not to be salty. An unbiased witness would say, this proves that the water does not come from the ocean;

the *trombe* did not carry it to the cloud. The biased witness will say, that proves that *trombes* freshen the ocean water. This state of mind resembles what physiologists call suggestion. A person living in a certain environment impregnated with prejudice, who has incorporated it into himself, as it were, makes no less use of his logical faculties. He applies them to the phenomenon which he has witnessed. Sure of his premises, feeling besides that he reasons correctly, he arrives at conclusions which would amaze an unbiased mind, but which he adopts without hesitation. Thus M. Peltier, a distinguished electrician, took great pains to explain that *trombes* did not pump water from the ocean, but that this water, reduced to vapor by an electric action, was transmitted to the cloud only as distilled water. More recently a simpler explanation has been found; it is that salt water poured into a cloud is in too small proportion to the water pre-existing in the cloud to communicate to it a perceptible saltiness.

That the reader may not think that I exaggerate the legend of the *trombes* of the ocean, I transcribe here a curious passage from "A New Voyage 'Round the World," (Dampier, Vol. I, sixth edition: London, 1717).

Shoals near Celebes. A Tornado and Spout.—The 30th day, we had a fresh land wind, and steered away south, passing between the 2 shoals, which we saw the day before. These shoals lye in Lat. 3 d. south, and about 10 leagues from the Island Celebes. Being past them, the wind died away, and we lay becalmed till the afternoon; then we had a hard tornado out of the south-west, and towards the evening, we saw two or three tornadoes, the first I had seen since I came into the East Indies; in the West Indies I had often met with them. A spout is a small ragged piece or part of a cloud hanging down about a yard, seemingly from the blackest part thereof. Commonly it hangs down sloping from them, or sometimes appearing with a small bending, or elbow in the middle. I never saw any hang perpendicularly down. It is small at the lower end, seeming no bigger than one's arm, but it is fuller toward the cloud, from whence it proceeds.

When the surface of the sea begins to work, you shall see the water, for about 100 paces in circumference, foam and move gently round till the whirling motions increase: and then it flies upward in a pillar, about 100 paces in compass at the bottom, but lessening gradually upwards to the smallness of the spout itself, there where it reacheth the

lower end of the spout, through which the rising sea-water seems to be converted into the clouds. This visibly appears by the clouds increasing in bulk and blackness. Then you shall presently see the cloud drive along, although before it seemed to be without any motion; the spout keeping the same course with the cloud, and still sucking up the water as it goes along, and they make a wind as they go. Then it continues for the space of half an hour, more or less, until the sucking is spent, and then breaking off, all the water which was below the spout, or pendulous piece of cloud, falls down again into the sea, making a great noise with its fall and clashing motion in the sea.

It is very dangerous for a ship to be under a spout when it breaks, therefore, we always endeavor to shun it, by keeping at a distance, if possibly we can. But for want of wind to carry us away, we are often in great fear and danger, for it is usually calm when spouts are at work, except only just where they are. Therefore men at sea, when they see a spout coming, and know not how to avoid it, do sometimes fire shot out of their great guns into it, to give it air or vent, that so it may break; but I never heard that it proved to be of any benefit.

And now being on this subject, I think it not amiss to give you an account of an accident that happened to a ship once on the coast of Guinea, sometime in or about the year 1674. One Captain Records of London bound for the coast of Guinea, in a ship of 300 tons and 16 guns, called the *Blessing;* when he came into the Lat. 7 or 8 degrees north, he saw several spouts, one of which came directly towards the ship, and he having no wind to get out of the way of the spout, made ready to receive it by furling his sails. It came on very swift and broke a little before it reached the ship, making a great noise and raising the sea round it, as if a great house or some such thing had been cast into the sea. The fury of the wind still lasted, and took the ship on the starboard bow with such violence, that it swept off the bowsprit and fore-mast both at once, and blew the ship all along, ready to overset it, but the ship did presently right again, and the wind, whirling round, took the ship a second time with the like fury as before, but on the contrary side, and was again like to overset her the other way. The mizzenmast felt the fury of this second blast, and was swept short off, as the fore-mast and bowsprit had been before. The main mast and maintop mast received no damage, for the fury of the wind (which was presently over) did not reach them. Three men were in the fore-top when the fore-mast broke, and one on the bow-sprit, and fell with them into the sea, but all of them were saved. I had this relation from Mr. John Canby, who was then quarter-master and steward, one Abraham Wise was chief mate, and Leonard Jefferies, second mate.

We are usually very much afraid of them: yet this was the only damage that ever I heard done by them. They seem terrible enough, the

rather as they come upon you while you lie becalmed, like a log in the sea, and cannot get out of their way: but though I have seen, and been beset by them often, yet the fright was always the greatest of the harm.

Is it not astonishing to see a man so judicious, accustomed to observing and appreciating all that he sees, and to relying on his own judgment under all circumstances, accepting with closed eyes the tales which he has heard told during his long career. For, finally, he himself never saw water ascend in the *trombes* which he describes so well; he never saw a *trombe* burst under its weight, and he would have laughed at a man who should come to him to propose to pump the bilge water of his ship with a muslin tube.

However, at the beginning of the next century, the attention of naturalists and physicists, accustomed to discussing facts began to be directed towards these phenomena, which up to this time had served only to frighten sailors and to furnish gossip in the forecastle. But they were divided into two categories; the physicists who started with nautical prejudices and adapted a theory to them, and those who rejected these errors disdainfully and tried to look the question in the face. Unfortunately for the latter, the known facts were still too incomplete. For example, almost nothing was known of the movement of translation of *trombes.* It could hardly be otherwise with the scattered observations which they had. It is only recently that we have learned by long observation on shore, to consider this motion of translation, not as an irregular phenomenon, without signification, but as something geometric, an essential of the phenomenon. To-day, a theory which could not account for it would be entirely unacceptable.

Franklin's Theory.—Franklin's ideas are recorded in a short memoir read before the Royal Society of London, June 3, 1796, under the title: *Physical and Meteorological Observations, Conjectures and Suppositions,* the knowledge of which I owe to Professor T. Luvini, of Turin.* This is the passage which is of interest to us.

Heavy fluids descending, frequently form eddies or whirlpools, as may be seen in a funnel, where the water acquires a circular motion receding every way from a center, and leaving a vacancy in the middle, greatest

* See the *Septembre Études*, Turin, 1884, pp. 104.

above, and lessening downwards, like a speaking trumpet, standing its big end upwards.

Air descending, or ascending, may form the same kind of eddies or whirlings, part of the air acquiring a circular motion, and receding from the middle of the circle by a centrifugal force, and leaving there a vacancy; if descending, greatest above and lessening downwards; if ascending, greatest below and lessening upwards like a speaking trumpet, standing its big end on the ground.

When the air descends with violence in some places, it may rise with equal violence in others, and form both kinds of whirlwinds.

The air in its whirling motion receding every way from the center or axis of the trumpet leaves there a vacancy which cannot be filled through the sides, the whirling air as an arch, preventing; it must then press in at the open ends.

The greatest pressure inwards must be at the lower end, the greatest weight of the surrounding atmosphere being there. The air entering rises within and carries up dust, leaves, and even heavier bodies that happen in its way, as the eddy or whirl passes over land.

If it passes over water the weight of the surrounding atmosphere forces up the water into the vacuity, part of which, by degrees joins with the whirling air, and adding weight, and receiving accelerated motion, recedes still farther from the center or axis of the trump, as the pressure lessens; and at last as the trump widens, is broken into small particles, and so united with air as to be supported by it, and become black clouds at the top of the trump.

Thus these eddies may be whirlwinds on land, waterspouts at sea. A body of water so rapid may be suddenly let fall, when the motion, etc., has not strength to support it, or the whirling arch is broken so as to admit the air; but if in the progressive motion of the whirl it has moved from the sea, overland, and then breaks, sudden, violent and mischievous torrents are the consequence.*

This is, notwithstanding some errors which it is needless to discuss, and in spite of the misconceptions which the great physicist accepted with closed eyes, a work truly masterly in its conciseness. It is the first time that *trombes* are clearly assimilated to the whirls which are produced in liquids.

The part played by centrifugal force, which prevents the air from approaching too near the axis of the whirl and which tends to maintain a vacuum there is perfectly indicated. It has been seen that it is upon this *role* that our explanation of the

* Franklin's Works, 3rd edition. Vol. 2, pp. 10-11.

origin of the calm in the center of storms is based. It is the first time that water is made to ascend in a *trombe* in the form of foam, or of impalpable mist. It is the first time that account has been taken of the progressive enlargement which a *trombe* undergoes at the point where the air draws the dust of water which augments the mass, and at the same time, the centrifugal force, a circumstance of which we will avail ourselves in the next paper. It is the first renunciation of the idea of making torrents of water in the liquid state inundate a cloud. We will find these ideas more or less perfect in the more recent theories of actual meteorologists.

Remark, however, as it is essential to our subject, an evident error. In comparing a *trombe* to a tube where the air whirls around an empty central region, Franklin supposes that the exterior air would not penetrate there except by the lower end. It penetrates there especially at the upper end, and it is on this account that the *trombe* does not exercise below a sensible aspiration. It is thus that the column of calm air in the interior of a cyclone comes from above (because it is above that the gyration establishes itself); and we know besides that the calm air is descending there and not ascending. Finally, Franklin assigns no cause for the foundation of these gyrations and neglects entirely an essential circumstance, which might have put him on the track, viz., the regular movement of translation of these *trombes* or tornadoes.

Buffon's and Spallanzani's Theory.—We have now arrived at an epoch when observers, free from preconceptions, examined the facts themselves and decided to reject the error of aspiring *trombes*. Franklin's friends had already protested against the current idea which he had adopted. Cadwallader Colden and Dr. Perkins relied upon an incontestable fact of observation which consists in that every *trombe* raises from the surface of the sea at its foot a circular hillock of water and foam, a mound convex externally, while it should be conical at the foot of the *trombe* if it is produced by aspiration toward the foot. Buffon went farther. He never observed a *trombe* himself, but he worked over excellent papers which were transmitted to him by

choice correspondents, especially by the astronomer *M. de la Nun,* who had frequent occasion to observe this phenomenon on the shores of the Island of *Reunion.* The following is what he says in his supplement:

"Every *trombe* is formed by an air whirl which is swallowed up among the clouds, and, swelling the lower cloud, pierces it, and descends with its envelope of viscous matter. And, as the complete *trombes* descend from the clouds to the surface of the ocean, the water trembles, boils and whirls at the place towards which the end of the *trombe* is directed, from the effect of the air which comes from the extremity of the *trombe,* like the tube of a bellows. The effect of this bellows upon the ocean will augment in proportion as they approach, and as the orifice of this tube, if it has become enlarged, will let more air pass, it has been thought, unwarrantably, that these *trombes* raise the water of the ocean and that they enclose a large quantity of it. What has strengthened this prejudice, has been the rains or rather the torrents which often fall in the vicinity of *trombes.* The canal in the middle of these *trombes* is always transparent, from whichever side it is viewed. If the water of the ocean appears to ascend, it is not in this canal, but only at the sides. Neariy all these *trombes* undergo inflections, and these inflections are often in a contrary sense, in the form of an S, of which the head is in the clouds and the tail in the water. The kinds of *trombes* of which we have spoken cannot contain water, neither for pouring into the ocean, nor for ascending to the clouds.

"Thus the *trombes* need be feared only on account of the velocity of the air which issues from their lower orifices. For it seems certain to all who have the opportunity of observing these *trombes,* that they are only composed of air enveloped in viscous cloud, and determined by its whirling toward the surface of the water."

Later, in 1785, a celebrated observer, Spallanzani, had occasion to observe *trombes* upon the Adriatic.*

The conclusions of his excellent notice seem to be in entire

* *Memorie di Matematica e Fisica della Societa Italiana.* Vol. iv., p. 43.

accord with the ideas of Buffon, to whom he has taken pains to refer in his memoir.

First Theory of Modern Meteorologists.—It must be confessed that the theories of Buffon and Spallanzani were much too incomplete. Besides it was difficult to conceive of *trombes* blowing upon the surface of the ocean like a forge bellows, even after introducing the notion of whirling movements, which was yet obscure, in spite of Franklin.

This outline of a theory was soon forgotten, and then the meteorologists who essayed at the beginning of the century to form a science, collected from all sides the tales of spectators who were less familiar than these two illustrious naturalists, with the art of observing, and who had heard only the aspiring power of *trombes* talked about. All declared, like the ancient navigators, that they had seen water ascend in water spouts—while the spectators of land-whirls saw whirling in them up to the clouds, dust, *debris*, pieces of iron and even roofs of houses. How could one doubt this mysterious power, before *trombes* which, in an instant, dried up the bed of a river, or lowered the level of the water of a lake by a meter?

A solution was necessary then, which conformed to the old error, still in existence. But as the meteorologists of that epoch had no idea of the whirling movements happily brought forward by Franklin, they looked for something else.

Now Franklin, to explain storms, at an epoch when their real nature was not even suspected, proposed, always with much reserve, the idea of rarefaction in the lower strata of the atmosphere, which would be produced by a local elevation of the temperature. This idea seemed confirmed by the barometric depression which accompanied storms. There should result from it an afflux of air more or less violent toward this locality and following a storm. Espy called attention to the fact that this affluent air from all parts towards a center would not fail to produce there an ascensional movement. If, then, some circumstance should prolong this ascensional movement, the first rarefaction, instead of culminating almost immediately, would persist in such a way as to give to the embryo tempest the devel-

opment and duration which is well known. Espy found this new element in the humidity of the lower air to which the first ascension is due. This air, reaching a certain height, dilates, cools, and would soon be in equilibrium of temperature and pressure with the surrounding air, and this would arrest the phenomenon. But if it is saturated with vapor of water a part of its humidity would condense in the region which it has attained. Now this condensation is accompanied by a certain release of that which is called latent heat. This heat, thus produced, is exactly the circumstance which would prolong the ascension, just beginning. Really the ascending air would be, thanks to the heat, at a higher temperature than the surrounding air, and would be again in its initial condition. It would then ascend higher; a new condensation of vapor taking place, would set free a new quantity of heat; and so when the ascension was once begun in humid air, it would persist as long as the lower air possessed a sufficient quantity of vapor of water. This theory invented for storms seemed to apply equally well to *trombes* and tornadoes. There was obtained thus an ascending column enlarging upwards, surrounded above by clouds formed by the condensation of the vapors carried with it, and the aspiration produced at the foot forced the lower air to rush in with violence. Are not these the characteristics of *trombes* carrying water from sea to cloud. Thus they were reunited in the same theory without recurring to the rather incomprehensible whirl of Franklin, with its interior void and its aspiration exercised below, etc., and by making use of the notions only of ordinary meteorology. It has recently been set forth in a classic work, which I make it a duty to quote from.*

"Between hurricanes and tornadoes, and likewise between them and *trombes,* there are only differences of dimension and intensity; the limits which separate them are ill-defined. All these phenomena owe their origin and their propagation to ascending currents, formed in an air charged with vapor, as we have already shown at length in speaking of the correlation of these phenomena, when we were studying hurricanes and whirls.

* *Grundzüge der Meteorologie,* Mohn, Berlin, 1883.

Wind *trombes* and tornadoes originate when the air is in a state of unstable equilibrium. A stable equilibrium takes place when one molecule of air, removed from its position, tends to resume it immediately. Then the temperature of the air continues to diminish slowly and regularly from below upward; in this case a molecule of air pressed from below upward, cools, becomes denser than the upper strata where it arrives, and redescends in consequence, to return to its first position. In the same way a molecule pushed down from above, warms, becomes lighter than that around it, and tends, in consequence to resume its first position. The equilibrium is unstable, on the contrary, when the temperature of the lower strata of the atmosphere rises rapidly as happens often in calm weather above a soil over-heated by the rays of the sun, then the lower strata become more rarefied than those immediately above. This case of unstable equilibrium responds to a rapid diminution of the temperature with the altitude. In this case the least perturbation suffices to destroy the equilibrium and compels the lower strata to traverse those which are immediately above, so as to gain, in the upper regions the place assigned them by their density and their weight. In this way an ascending current may suddenly be produced, and if the air is much charged with the vapor of water, the ascending movement will be effected more readily. Much more when the air reaches a height where, in consequence of its dilatation and its cooling, the vapor commences to precipitate, the latent heat of the vapor contributes to elevate the temperature of the air and to render it lighter than that of the mass which is at the same altitude. Air humid, weather very calm, and sun very hot, these are the conditions then, essential to the unstable equilibrium of the atmosphere, and in such circumstances, local ascending currents may form, which, in the conditions assigned, will produce *trombes*, tornadoes and even cyclones."

We give also the description of *trombes* by the same author.

"Ascending currents are encountered equally, with or without gyratory movement in the waterspouts or in sand *trombes* which represent tornadoes in a reduced scale. *Trombes* form on

water or on land; they appear like slender, dark columns, which descend from the clouds in funnel shape, and which, when they touch the soil or the surface of the water, aspire sand and other light material which they carry off, whirling them through the air. When they form on the ocean they whip the water and raise it towards the mouth, giving it often a sort of gyration. They describe more or less regular trajectories over the surface. They exercise a powerful aspiration so that it is dangerous to encounter them. The rotatory motion of *trombes* may be effected from right to left or from left to right; it generally depends on the direction of the first currents which have flowed in towards their foot, in consequence of accidental circumstances."

We have now returned by a somewhat devious route to the idea that *trombes* carry water from the sea to the clouds. But if the purely physical part of this theory can be sustained in what concerns the lower ascension of the humid super-heated lower air, there is nothing there which applies to *trombes*. The long discussions which I have had to sustain against the partisans of this theory may be summed up as follows:

Picture to yourself a master obliged to give to his pupils this explanation of tornadoes. He has already described the particular condition of the atmosphere when in calm weather, in certain deserts, the phenomenon of the mirage is produced. The soil has been strongly heated by an ardent sun; the temperature of the lower strata of air has been raised to an unusual degree. This air having become too light has a tendency to rise in a mass, but it is retained by the pressure of the upper layers. There is an unstable equilibrium which the least accident suffices to disturb, such as a falling leaf or a flying bird. In an accidental issue, thus produced, the lower air will begin to rise.

Up to this time the pupils have understood. They will understand further if this is said to them: the unstable equilibrium having thus been broken at one point, it will break more and more everywhere else; that the air rising vertically on the spot would soon re-establish the stable equilibrium, which is the

normal condition of the atmosphere. But the Professor will be obliged to undeceive them. He will state that the air cannot rise except by the first opening, in such a manner as to form a durable ascending column. The air must pass horizontally for a long distance over the soil to enable it to rise vertically through this opening, exactly as if the surface were covered by a great board pierced with an orifice. But what will be more embarrassing is the explanation of how it happens that the tornadoes turn with the frightful violence so well known in the United States. Air inflowing from all sides towards an opening constitutes a centripetal movement, and not a gyratory movement in a definite direction. Another difficulty: everybody knows that tornadoes travel with great swiftness in a direction not at all arbitrary. How can this be explained when they are produced in the midst of an absolute calm in the atmosphere? What a position for a professor whose duty it is to give instruction in a country profoundly interested in knowing the truth about that one of its plagues to which it is most exposed! Most of them would refuse so ungrateful a task, while science can produce no better explanation of these phenomena.

I called attention to several other impossibilities in the course of these debates, but in vain. I had stumbled against a *parti-pris.*

(TO BE CONTINUED.)

VINES' LAWS OF RECURVATURE.

By Arthur H. Dutton.

The laws of Viñes relative to the normal points of recurvature of the trajectories of West Indian hurricanes are so attractive that one is apt to be prejudiced in their favor, but the importance claimed for them is so great that it is worth while to consider them with unusual care before accepting them.

Mr. Everett Hayden, the able marine meteorologist of the U. S. Hydrographic Office, interprets the laws as follows:

"In June (and October) the vertex of the parabola is in

about latitude 20° to 23° N; in July (and September) 27° to 29°, and in August 30° to 32°."

The supports for this theory are (1) the authoritative statement of Viñes, and (2) the alleged fact that all recorded October hurricanes that have crossed Cuba have done so from SW to NE.

For the purpose of verifying these laws of normal recurvature; the writer has studied the paths of all the tropic storms of which he could find any authentic record. But it has been claimed in defense of the laws that the vast majority of storm-tracks published in past years were determined from too incomplete data and by too unreliable methods to be of much weight in refuting the laws. (The same reasoning will of course hold good in confirming them). Therefore, we will consider in detail only the hurricanes which occurred during the years 1887, 1888 and 1889; taking the months of August, September and October as the typic hurricane months, and accepting as correct the paths indicated in the records, published and unpublished, of the U. S. Hydrographic Office.

In 1887 we have records of the following storms:

(1) August 13–29. Apex of path in latitude 30° N; within limits.

(2) August 20–31. Apex of path in latitude 28° N; 2° to southward of limits.

(3) September 1–9. Moved to eastward; did not recurve.

(4) September 1–7. Apex of path in latitude 33° N; 4° to northward of limits.

(5) September 11–21. Moved to westward; did not recurve.

(6) September 15–19. Apex of path in latitude 30° N; 1° to northward of limits.

(7) September 24–26. Moved to eastward; did not recurve.

(8) October 8–12. Apex of path in latitude 22° N; within limits.

(9) October 9–11. Moved to westward; did not recurve.

(10) October 16–20. Apex of path in latitude 25° 40′ N; 2° 40′ to northward of limits.

(11) October 11–24. Apex of path in latitude 26° 40′ N; 3° 40′ to northward of limits.

(12) October 22–23. Moved to westward; did not recurve.

(13) October 29–31. Moved to eastward; did not recurve.

(14) October 30–31. Apex of path in latitude 32° N; 9° to northward of limits.

In 1888 the following storms:

(15) August 11–25. Apex of path in latitude 30° N; within limits.

(16) September 1–7. Moved to westward; did not recurve.

(17) September 6–15. Apex of path in latitude 30° N; 1° to northward of limits.

(18) September 24–27. Moved to eastward; did not recurve.

(19) October 10–15. Moved to eastward; did not recurve.

(20) October 24–25. Apex of path in latitude 31° N; 8° to northward of limits.

In 1889 the following storms are noted:

(21) September 1–14. Moved to westward; did not recurve.

(22) September 3–11. Apex of path in latitude 29° N; within limits.

(23) September 13–20. Apex of path in latitude 25° 30′ N; 1° 30′ to southward of limits.

(24) September 15–19. Moved to westward; did not recurve.

(25) September 19–25. Apex of path in latitude 20° N; 7° to southward of limits.

(26) October 1–6. Apex of path in latitude 25° N; 2° to northward of limits.

(27) October 6–7. Moved to eastward; did not recurve.

(28) October 9–11. Moved to westward; did not recurve.

(29) October 9–12. Apex of path in latitude 17° N; 3° to southward of limits.

By the expression "did not recurve," it is meant that there was no recurvature in the sense of Viñes' laws—that is, the storm did not change its course from a westerly to an easterly direction.

Summarizing, we find from the above table that, out of twenty-nine tropic storms, only four recurved within the limits specified;

eight recurved to the northward and four to the southward of the limits; while thirteen did not recurve at all, or may be considered indeterminate. In other words, less than 14 per cent. obeyed the laws.

The first objection to this statement of what has actually occurred will probably be raised on the ground that these twenty-nine storms were not all true hurricanes. To meet this objection, we will take only the storms numbered 1, 2, 4, 5, 6, 8, 11, 15, 16, 17, 21, 22 and 26. There can be no doubt that these were true hurricanes. Out of these thirteen, four recurved within the limits; five to the northward; one to the southward; and three were indeterminate. That is, about 31 per cent. obeyed the laws.

Taking the paths of thirty-two August and September hurricanes that occurred during previous years, and subjecting them to the same analysis, it has been found that only eight, or 25 per cent. obeyed the laws.

These figures speak for themselves, Is the theory sufficiently borne out by observation to render it reliable? Is it sufficiently well established to authorize meteorologists to instruct mariners and others to take it into serious consideration when maneuvering for the safety of their vessels?

THE INTERNATIONAL HYDROLOGICAL AND CLIMATOLOGICAL CONGRESS AT PARIS.

By A. Lawrence Rotch.

As was announced in this Journal, the Congress which met in Paris in October, 1889, was the outcome of the first International Hydrological and Climatological Congress held at Biarritz in 1886. It was, however, noticeable that many prominent participants in the first Congress were absent in Paris, and that the attendance there was far inferior to that at Biarritz. The following foreign governments, through their commissions at the Paris Exposition, sent delegates, viz.: United States, Austria, Italy, Spain, Belgium, Roumania, Turkey, Brazil, Mexico, Chili, Bolivia, Japan and Hawaii.

M. Renou, as president of the committee of organization, called the Congress to order in the Trocadéro Palace and made the opening address, after which these officers were appointed:

Hon. President, the Minister of the Interior; President, M. Renou, Director of the Park of St. Maur Observatory and President of the French Meteorological Society; Hon. Vice-President, Prof. Winternitz, of the University of Vienna; National Vice-Presidents, Drs. Danjoy, Constantin Paul and Fines; Foreign Vice-Presidents, M. M. Lancaster (Belgium), Ceccherelli (Italy) and Caldéron (Spain); General Secretary, Dr. de Ranse; Secretaries, Drs. Schlemmer and De la Harpe.

The sections of scientific and medical hydrology each chose officers, those of the former section being as follows:

President, Dr. Labat, member of the Medical Hydrological Society of Paris; National Vice-Presidents, Drs. Bouloumié and Barėty; Foreign Vice-Presidents, M. Bonkowsky-Bey (Turkey) and Dr. Poskin (Belgium.)

The Climatological Section was thus officered: President, M. Lemoine, chief engineer of the Ponts et Chaussées and Vice-President of the French Meteorological Society; National Vice-Presidents, Drs. de Valcourt and Hameau; Foreign Vice-Presidents, M. M. Faralli (Italy), Wada (Japan) and Rotch (United States); Secretary, Dr. Deligny.

Although the Congress was divided into three sections—scientific hydrology, medical hydrology and climatology—on account of the close connection between them, the sections of scientific hydrology and climatology were united, and for the same reason the three sections sometimes held general sessions, all the sessions being at the School of Medicine. The committee of organization had prepared a series of questions to be discussed, most of which formed the subjects of reports which were previously distributed to members and which served as the basis of discussion. The following are the most important papers presented to the sections of scientific hydrology and climatology: Precautions to be taken in determining the precise temperature of thermal springs, by M. Renou. The author in this report described the best methods of observing water temperatures and

called attention to the necessity of using thermometers whose zero points had been rendered invariable. He also explained the proper mode of exposing thermometers for observing air temperatures as exemplified in the shelter used at the Park of St. Maur. In the discussion which followed, M. Wada stated the effect of cyclonic action in influencing the temperature of springs in Japan. According to this speaker the temperature of the springs increased while the volcanic activity decreased before the passage of a barometric depression. An increase in their temperature was also noted before earthquake shocks. M. Symons recalled his trip to the Pyrenees, undertaken by authorization of the Royal Society, to verify the temperatures of the thermal springs, which he found had not changed appreciably during the last fifty years.

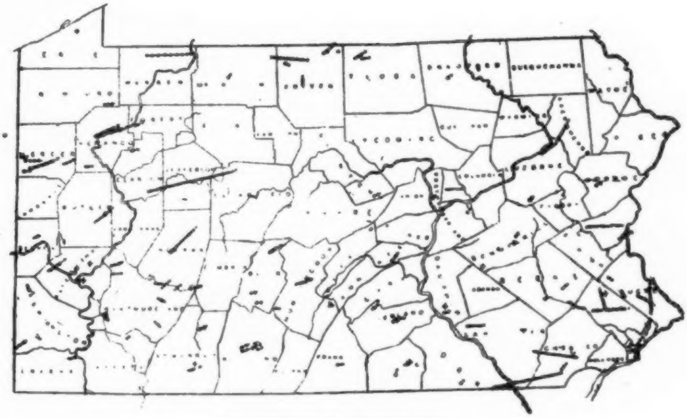
M. Lahillonne presented a paper on maritime vs. mountain climates, in which he proposed a graphic representation of their peculiarities by two superposed curves, one indicating the temperature, the other the dewpoint. Prof. Morales gave an account of the mineral springs of Mexico, and M. Guerrerio described the work which he had accomplished at San Fernando, Portugal, to render a large tract of marshy land habitable by planting eucalyptus trees and thus diminishing the diurnal range of temperature and increasing the humidity. Dr. Labat reviewed his interesting report on the origin of the gases contained in mineral waters and on the part which they play in the properties of these waters, in which he concluded that no absolute theory of their origin explained all the facts observed. Dr. Labat also presented a report on the comparison and classification of sanitary stations with respect to their climatic conditions, dividing them from the influence of mountains and sea into mountain and maritime stations suitable for winter and summer. He reviewed the chief health resorts from this point of view, noting their advantages and disadvantages.

Dr. Chiais spoke of the importance of atmospheric water vapor, which he likened to a protecting mantle, upon the human organism. For each climate the inferior limit of humidity which can be borne without injury should be determined, after

which the psychrometer can be consulted by the invalid. Dr. Leudet read a report on the action of high altitudes upon chest diseases in which he concluded that mountain climates have an incontestable action, very efficacious when it is a question of prevention, but relatively little when it is necessary to cure. Dr. Deligny considered the relations of phthisis and high altitude, stating that he did not believe that the latter gave immunity from the disease.

M. Lemoine submitted to the Congress a provisory programme for a course of climatology which for physicians could be combined with a course of hydrology contained in a dozen lessons. It would consist of two principal parts, the study of the chief meteorological elements and the study of certain climates with some rudimentary ideas of weather forecasting. The meteorological elements considered would be atmospheric pressure, air and water temperatures, wind, cloud, humidity, rain and atmospheric electricity. Some attention would be given to the permeability of the soil, and the climates most used by physicians would be studied. Dr. Durand-Fardel's proposed programme for a course of hydrology, contained in his report, was criticised by Dr. Labat, Prof. Winternitz and others.

At the closing session, Rome was chosen as the place of meeting of the next congress in 1892. During the week a number of excursions were made. At Pierrefonds a dinner was given by the municipality and the thermal establishment and chateau visited, as was also the palace at Compiegne. Another day, part of the congressionists visited the meteorological observatory at the Park of St. Maur, the others going to Enghien where they were shown the thermal establishment and tendered a lunch. Under the guidance of Dr. Labat, the pavilion of mineral waters at the Exposition was inspected, and by invitation of Dr. Proust the museum of hygiene of the School of Medicine was visited. The proposed final tour among the hydro-mineral stations of the Vosges was abandoned on account of the unfavorable weather. On the last day of the Congress the principal foreign delegates were entertained at dinner by Dr. de Ranse, the general secretary, nd many international courtesies were exchanged.



TORNADOES IN PENNSYLVANIA.

STATE TORNADO CHARTS.—PENNSYLVANIA.

BY LIEUT. JNO. P. FINLEY, SIGNAL SERVICE, U. S. A.

TABLE I.—*Tornadoes in Pennsylvania.*

Period of observation, 78 years,—1811-1888.
Total number of storms,—90.
Year of greatest frequency, 1887,—19 storms.
Average yearly frequency,—3.8 storms.
Year in past (10) ten years, no report of storms,—none.
Month of greatest frequency, May,—24 storms.
Day of greatest frequency, May 10th,—11 storms.
Hour of greatest frequency,—5 to 6 P. M.
Month without storms,—November.
Prevailing direction of storm movement,—NE. and ENE.
Region of maximum storm frequency,—west and southwest portions.

TABLE II.—*A Chronological Table showing the location, date and time of occurrence and general character of formation and movement of Tornadoes in the State of Pennsylvania, for a period of 78 years, from 1811 to 1888.*

County.	Month and Day.	Year.	Time.	Direction.	Form of Cloud.	Width of Path in Feet.
Montgomery	......	1811	......	......	......	......
Washington	March —.	1830	Sundown.	SE.	......	Narrow.
Lancaster	March 22.	1830	7 p. m.	E	......	1,320.
Bucks	June 6	1830	Afternoon.	SE.	......	600 to 1,800.
Lancaster	June 2.	1832	"	E.	......	2,640.
Potter	......	1833	......	SE.	......	......
York, Lancaster and Chester	June —.	1833	Afternoon.	E 20° N.	Funnel.	660.
Schuylkill	June 11.	1833	Night.	......	......	......
Potter	March 20.	1834	4 p. m.	N.	......	......
Luzerne and Lackawanna	July 2.	1834	Afternoon.	NE.	......	......
McKean	May 5.	1837	4 p. m.	E 5° S.	......	990 to 1,155.
York	July 8.	1840	8:30 p. m.	NE.	......	......
Philadelphia	July 13.	1840	1 p. m.	......	Whirlwind.	......
Washington	January 20.	1854	......	......	......	......
Bradford	August 10.	1854	Afternoon.	NE.	......	......
Clarion, Armstrong, Jefferson and Clearfield	May 29.	1860	About noon.	ENE.	Funnel.	330 to 990.
Lancaster	July 17.	1865	Afternoon.	NE.	"	1,320.
Adams	June 29.	1875	p. m.	NE.	"	......
Erie	July 26.	1875	Afternoon.	......	......	......
Philadelphia	August 11.	1875	......	......	......	......
Pike	October 30.	1875	Afternoon.	NE.	Funnel.	......
Somerset	August 7.	1876	p. m.	......	"	......
Northampton	June 21.	1877	Afternoon.	NE.	"	......
Chester	July 1.	1877	3:30 p. m.	E 10° S.	"	300 to 900.
Allegheny	August 30.	1877	......	......	......	......
Allegheny	July 4.	1878	3 p. m.	NE.	......	......
Allegheny	August 16.	1878	Afternoon.	......	......	100 to 300.
Schuylkill	July 11.	1879	......	......	......	......
Adams	September 4.	1879	Afternoon.	NNE.	Funnel.	60 to 100.
Dauphin	April 16.	1880	"	......	......	......
Schuylkill	June 13.	1880	"	NE.	......	......
Indiana	June 7.	1881	"	NE.	Funnel.	150 to 500.
Northumberland	August 6.	1881	"	NE.	......	1,200 to 1,500.
Fayette	April 19.	1882	4 p. m.	NE.	Funnel.	600.
Butler	June 30.	1882	7:10 p. m.	E.	"	1,320.
Washington	June 18.	1883	6 p. m.	SE.	"	......
Potter	July 5.	1884	11:50 a. m.	NE.	......	......

TABLE II.—*Continued.*

County.	Month and Day.	Year.	Time.	Direction.	Form of Cloud.	Width of Path in Feet.
McKean	September 28.	1884	5:20 p. m.	NE.	Funnel.	80 to 150.
Washington	December 6.	1884	6 p. m.	NE.	...	150.
Mercer	June 5.	1885	Bet. 1 and 2 p. m.	E.	...	1,320.
Bucks	August 3.	1885	4 p. m.	N.	Funnel.	300.
Montgomery	"	1885	3:30 p. m.	NE.	"	...
Bucks	"	1885	p. m.	NW.?	"	20.
Bucks	"	1885	4:30 p. m.	N 33° E.	"	...
Chester	"	1885	5:30 p. m.	NNE.	"	...
Juniata	"	1885	2:30 p. m.	NE.	"	1,200.
Montgomery	"	1885	11:30 a. m.	N 10° W.?	"	300.
Indiana	May 10.	1886	5:45 p. m.	NE.	...	...
Westmoreland	"	1886	5:40 p. m.	Easterly.	Funnel.	600 to 900.
Berks	"	1886	"	NE.	"	600.
Westmoreland	"	1886	6 p. m.	NE.	"	600 to 1,320.
Westmoreland	"	1886	5:30 p. m.	ESE.	"	...
Westmoreland	"	1886	Bet. 5 and 6 p. m.	E.	...	...
Beaver	"	1886	4 p. m.	ESE.	Funnel.	...
Westmoreland	"	1886	5 p. m.	S 65° E.	...	...
Allegheny	"	1886	Evening.	...	...	...
Westmoreland	"	1886	4:30 p. m.	Easterly.	Rolling cloud.	1,320 to 5,280.
Cambria	"	1886	About 6 p. m.	"	...	...
Warren	June 17.	1886	9 a. m.	E.	Funnel.	175 to 825.
Mercer	July 13.	1886	Evening.	Easterly.	...	...
Luzerne	September 19.	1886	About 4 p. m.	NE.	Funnel.	...
Tioga	"	1886	3 p. m.	NE.	"	...
Mercer	February 11.	1887	11 a. m.	NE.	...	1,320 to 2,640.
Huntington	"	1887	Noon.	NE.	Funnel.	Narrow.
Blair	"	1887	"	NE.	"	"
Clinton	"	1887	11 a. m.	NE.	Inverted cone.	"
Forest	"	1887	"	NE.	...	2,640.
Somerset	May 3.	1887	Evening.	Easterly.	...	Narrow.
Bedford	"	1887	Afternoon.	E.	Funnel.	1,320 to 2,640.
Blair	"	1887	Evening.	ENE.	"	800 to 2,000.
Somerset	May 4.	1887	"	NE.	Inverted cone.	1,320.
Bedford	"	1887	6 p. m.	NE.	Funnel.	1,320.
Blair	"	1887	5:30 p. m.	NE.	...	Narrow.
Huntington	June 2.	1887	Morning.	Easterly.	Funnel.	300.
Northampton	July 16.	1887	6:30 p. m.	NE.	...	900.

TABLE II.—*Concluded.*

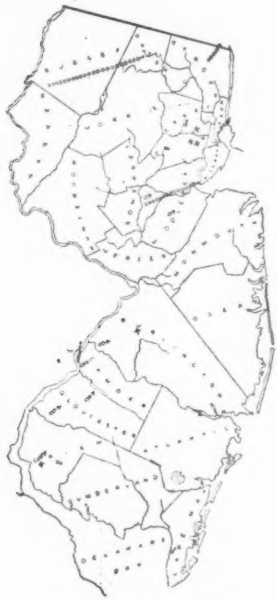
County.	Month and Day.	Year.	Time.	Direction.	Form of Cloud.	Width of Path in Feet.
Cumberland	July 17.	1887	3 p. m.	Easterly.	Funnel.	800 to 1,200.
Tioga	August 1.	1887	2:30 p. m.	"	....	Narrow.
Venaugo	August 5.	1887	Evening.	"	....	"
Cumberland	August 11.	1887	Afternoon.	ENE.	Funnel.	2.640.
Dauphin	"	1887	5 p. m.	E.	....	1.320.
Philadelphia	"	1887	6:15 p. m.	ENE.	Inverted cone.	800 to 1,500.
Allegheny	April 5.	1888	4 p. m.	NE.	Funnel.	1,200.
Mercer	"	1888	Night.	E.	....	Narrow.
Greene	"	1888	Evening.	E.	....	"
Venaugo	May 28.	1888	2:30 p. m.	E.	Funnel.	"
Venaugo	"	1888	3 p. m.	E.	"	2.640.
Clarion	"	1888	Afternoon.	E.	"	1.320.
Crawford	"	1888	"	ENE.	....	Narrow.
Franklin	"	1888	4:30 p. m.	NE.	Funnel.	2.640.
Monroe	July 31.	1888	9 p. m.	NE.	....	700 to 1,200.

TABLE III.—*Relative frequency of Tornadoes by months and days, for Pennsylvania.*

The index figures to the right and above the dates show how many times tornadoes occurred on that day of the month.

Month.	Day of Month.	No. of Days.	Total No. of Tornadoes per month.
January	20	1	1
February	$(11)^5$	1	5
March	20, 22 and (—)	3	3
April	$(5)^3$, 16 and 19	3	5
May	$(3)^3$, $(4)^3$, 5, $(10)^{11}$, $(28)^5$ and 29	6	24
June	$(2)^2$, 5, 6, 7, 11, 13, 17, 18, 21, 29, 30 and (—)	12	13
July	1, 2, 4, 5, 8, 11, $(13)^2$, 16, $(17)^2$, 26 and 31	11	13
August	1, $(3)^7$, 5, 6, 7, 10, $(11)^4$, 16 and 30	9	18
September	4, $(19)^2$ and 28	3	4
October	30	1	1
December	6	1	1
(—) Blank	$(—)^2$	1	2
Total		52	90

NOTE.—The (—) signifies date missing



TORNADOES IN NEW JERSEY.

STATE TORNADO CHARTS.—NEW JERSEY.

By LIEUT. JNO. P. FINLEY, SIGNAL SERVICE, U. S. A.

TABLE I.—*Tornadoes in New Jersey.*

Period of observation, 67 years,—1822–1888.
Total number of storms,—19.
Year of greatest frequency, 1888,—6 storms.
Average yearly frequency,—1.6 storms.
Years in past ten (10) years, no report of storms, 1879 to 1884, inclusive.
Month of greatest frequency, July—5 storms.
Day of greatest frequency, July 5th,—2 storms.
Hour of greatest frequency, 3 to 4 P. M.
Months without storms,—Jan., Feb., March, May and Dec.
Prevailing direction of storm movement, NE.
Region of maximum storm frequency, northeast portion.

TABLE II.—*A Chronological Table, showing the location, date and time of occurrence, and general character of formation and movement of Tornadoes in the State of New Jersey for a period of 67 years, from 1822 to 1888.*

County.	Month and Day.	Year.	Time.	Direction.	Form of Cloud.	Width of Path in Feet.
Salem	September 21.	1822				100.
Middlesex	June 19.	1835	5:12 p. m.	ENE.	Inverted cone.	600 to 1,200.
Essex	October 9.	1839			Funnel.	
Sussex	April 22.	1867	4 p. m.	E.	"	
Burlington	November 23.	1874				
Salem	July 29.	1875	3 p. m.	ESE.	Funnel.	
Essex	August 11.	1875		NNE.		200 to 500.
Cape May	August 17.	1876	Afternoon.	NE.		
Union	July 19.	1877				
Camden	August 3.	1885	3:20 p. m.	NNE.	Funnel.	1,200.
Bergen	October 4.	1885	1:15 p. m.	NE.	"	500.
Hudson	September 12	1886	6 p. m.	NE.	"	
Burlington	July 16.	1887	7:45 p. m.	ENE.	"	2,640.
Camden	June 23.	1888	5 p. m.	E.	"	1,200.
Middlesex	July 5.	1888	4:30 p. m.	NE.	"	1,320.
Somerset	"	1888	3:45 p. m.	NE.	"	800 to 1,200.
Salem	August 21.	1888	4 p. m.	NE.	"	1,300.
Gloucester	September 16	1888	7:30 p. m.	NE.	Inverted cone.	2,640.
Gloucester	September 17	1888	6 p. m.	NE.		Narrow.

TABLE III.—*Relative frequency of Tornadoes by months and days, for New Jersey.*

The index figures to the right and above the dates show how many times tornadoes occurred on that day of the month.

Month.	Day of Month.	No. of Days.	Total No. of Tornadoes per month.
April	22	1	1
June	19 and 23	2	2
July	(5)[2], 16, 19 and 29	4	5
August	3, 11, 17 and 21	4	4
September	12, 16, 17 and 21	4	4
October	4 and 9	2	2
November	23	1	1
Total		18	19

STATE TORNADO CHARTS.—DELAWARE.

BY LIEUT. JNO. P. FINLEY, SIGNAL SERVICE, U. S. A.

TABLE I.—*Tornadoes in Delaware.*

Period of observation, 18 years, 1871–1888.

Total number of storms,—5.

Year of greatest frequency, 1888,—3 storms.

Average yearly frequency,—0.03 storms.

Years in past ten (10) years, no report of storms,—1879, 1880, 1881, 1882, 1883, 1884 and 1886.

Month of greatest frequency, August,—3 storms.

Day of greatest frequency, August 21st,—2 storms.

Hour of greatest frequency, 5 to 6 P. M.

Months without storms,—January, February, March, April, May, July, October, November and December.

Prevailing direction of storm movement, NE.

Region of maximum storm frequency, northern portion.

TABLE II.—*A Chronological Table, showing the location, date and time of occurrence, and general character of formation and movement of Tornadoes in the State of Delaware for a period of 18 years, from 1871 to 1888.*

County.	Month and Day.	Year.	Time.	Direction.	Form of Cloud.	Width of Path in Feet.
New Castle	August 3.	1885	4:45 p. m.	Easterly.	Funnel.	900.
New Castle	June 22.	1887	12:40 p. m.	NE.	"	Narrow.
New Castle	August 21.	1888	5 p. m.	NE.	"	"
New Castle	"	1888	6:20 p. m.	NE.	"	600.
Kent	September 17.	1888	Evening.	NE.	"	Narrow.

TABLE III.—*Relative frequency of Tornadoes by months and days, for Delaware.*

The index figures to the right and above the dates show how many times tornadoes occurred on that day of the month.

Month.	Day of Month.	No. of Days.	Total No. of Tornadoes per month.
June	22	1	1
August	3 and $(21)^2$	2	3
September	17	1	1
Total		4	5

ROYAL METEOROLOGICAL SOCIETY.

At the February meeting the following papers were read:

1. "Observations on the motion of dust, as illustrative of the circulation of the atmosphere, and of the development of certain cloud forms," by the Hon. Ralph Abercromby, F. R. Met. Soc. The author has made numerous observations on the motion of dust in various parts of the world, especially on deserts on the west coast of South America. He finds that the wind sometimes blows dust into streaks or lines, which are analogous to fibrous or hairy cirrus clouds; sometimes into transverse ridges and furrows, like solid waves, which are analogous to certain kinds of fleecy cirro-cumulus clouds; sometimes into crescent-shaped heaps with their convex side to the wind, which are perhaps analogous to a rare cloud form call "mackerel scales"; sometimes into whirlwinds, of at least two, if not of three varieties, all of which present some analogies to atmospheric cyclones; sometimes into simple rising clouds, without any rotation, which are analogous to simple cumulus-topped squalls; and sometimes into forms intermediate between the whirlwind and simple rising cloud, some of which reproduce in a remarkable manner the combination of rounded, flat, and hairy clouds that are built up over certain types of squalls and showers. Excessive heating of the soil alone does not generate whirlwinds; they require a certain amount of wind from other causes to be moving at the time. The general conclusion is, that when the air is in more or less rapid motion from cyclonic or other causes, small eddies of various kinds form themselves, and that they develop the different sorts of gusts, showers, squalls and whirlwinds.

2. "Cloud Nomenclature," by Capt. D. Wilson-Barker, F. R. Met. Soc. The author proposes a simple division of cloud forms under two heads, viz., Cumulus and Stratus, and recommends that a more elaborate and complete division should be made of these two types. A number of photographs of clouds were exhibited on the screen in support of the proposal.

3. "An Optical Feature of the Lightning Flash," by E. S.

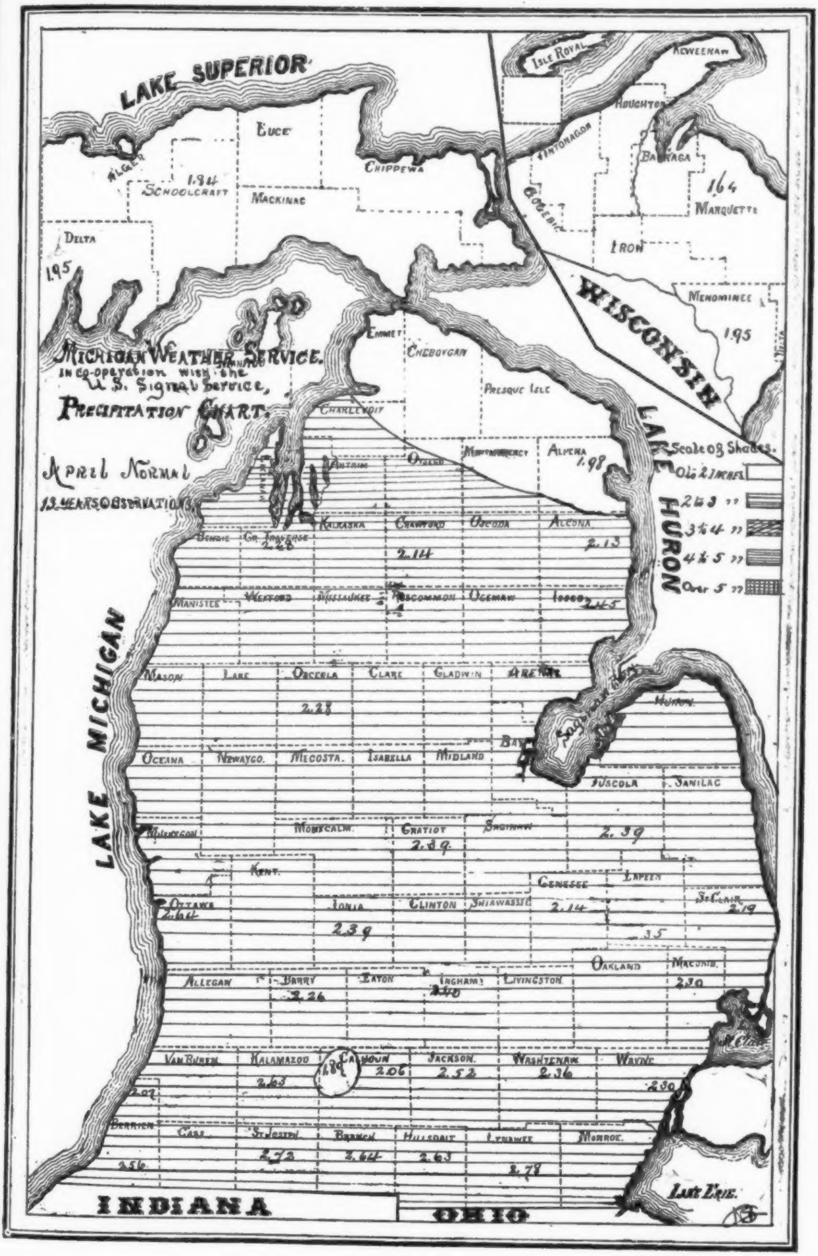
Bruce, M. A., F. R. Met. Soc. It has been stated in the Report of the Thunderstorm Committee of the Royal Meteorological Society that there is not the slightest evidence in the photographs of lightning flashes of the angular, zig-zag or forked forms commonly seen in pictures. The author, however, believes that this is an optical reality, as the clouds on which the projection of the flash is cast are often of the cumulus type, which afford an angular surface. In support of this theory he exhibited some lantern slides of lightning playing over clouds.

RAINFALL IN MICHIGAN—APRIL.

BY N. B. CONGER.
Director State Weather Service.

The average rainfall for the month of April for the State is 2.52 inches, which is about the same average as for March, and the distribution is nearly the same in each section as for the month of March. The rainfall in the upper peninsula still remains less than two inches, although the amount for this month approaches nearer the two inch mark than in the previous months.

The rainfall for this month comes mostly in showers that may be heavy or light as the case may be, but as a general rule not a long season of rainfall is to be noted in the records of the past. The heaviest rainfalls have been recorded in the different portions of the State in the years 1878, 1880, 1883, 1884, and 1888, and the years in which light rainfall occurred were 1872–3–4–5–6, 1881, 1882, 1887 and 1889. It appears from these records of fourteen years that heavy rainfall has occurred in five years, while a light fall of rain has occurred in nine. These records cover the whole State and it must be always remembered in considering the rainfall of Michigan, that while one portion of the State may have light rainfall, another portion will have copious showers. In this connection it would be advantageous to cite the rainfall for 1889, which in the southern, central and eastern part of the northern sections was considerably below the aver-


MICHIGAN WEATHER SERVICE.
in co-operation with the U.S. Signal Service,
PRECIPITATION CHART.
April Normal
13 YEARS OBSERVATIONS.
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
WISCONSIN
INDIANA
OHIO
Lake Erie.
Scale of Shades.
Over 5 "
Isle Royal
Keweenaw
Houghton
Ontonagon
Baraga
Gogebic
Marquette
1.64
Iron
Menominee
1.95
Alger
Luce
Chippewa
1.84
Schoolcraft
Mackinac
Delta
1.95
Emmet
Cheboygan
Presque Isle
Charlevoix
Antrim
Otsego
Montmorency
Alpena
1.98
Kalkaska
Crawford
Oscoda
Alcona
2.13
Benzie
Gr. Traverse
2.14
Manistee
Wexford
Missaukee
Roscommon
Ogemaw
2.45
Mason
Lake
Osceola
Clare
Gladwin
Arenac
2.28
Huron
Bay
Oceana
Newaygo.
Mecosta.
Isabella
Midland
Tuscola
Sanilac
Montcalm.
Gratiot
2.39
Saginaw
2.39
Kent.
Genesee
Lapeer
Ottawa
Ionia
Clinton
Shiawassee
2.14
St Clair
2.19
2.39
Oakland
Macomb.
2.30
Allegan
Barry
2.26
Eaton
Ingham
Livingston
Van Buren
Kalamazoo
Calhoun
2.06
Jackson.
2.52
Washtenaw
2.36
Wayne
2.30
Berrien
Cass
St Joseph
2.72
Branch
2.64
Hillsdale
2.63
Lenawee
2.78
Monroe.

age, and in the upper peninsula the rainfall was above the average.

The first tier of counties in the southern part of the State begin to receive the increase in rainfall which begins in this month and increases during May and June, the latter being the rainy month of the year in this state. There are no marked peculiarities in the rainfall of this month, and the records reveal but slight departures from the averages, with the exception that the tendency is for the rainfall to be under the average than over it, that is, it would be more in consonance with the records to look for a light rainfall for April than for heavy rainfall.

CORRESPONDENCE.

LOCAL INFLUENCES IN TORNADOES.*

An old friend once told me of a case in point, of which he was an eye witness.

At a point on the Susquehanna river, a few miles from its mouth, where the river runs almost directly south, and is more than a mile wide with an average depth of not more than three or four feet, the western approach to the river, a long gradual slope, whilst on the eastern side the hills are high and abrupt.

One sultry afternoon, he says, a tornado cloud was seen coming from the west, gathering force as it came.

On reaching the river it was seen to be lifting large quantities of water and even rocks of considerable size from its bed, which it continued to do until within a short distance of the eastern shore where a perceptible change took place in the form of the cloud, the currents of air from the east had been cut off by the sudden interposition of the almost perpendicular river banks. The supplying currents now only coming from the west, and failing to meet the opposition of those from the east, the spiral column, where its most energetic force was exerted at the apex of the cone, was suddenly cut off by the high hills,

* From a private communication; printed with the consent of the author. The local references are to the vicinity of West Chester, Penn., near which Mr. Sharpless lives.

and then its base being so broadened the currents could no longer sustain the immense weight of water it was carrying.

Then came what is known as a cloud burst, and an immense body of water was discharged upon the tops of the hills in floods which swept everything movable including rocks of many tons weight into the surrounding ravines and back into the river.

That hills and forests have an influence in greatly changing the course of a tornado cloud I am assured, by observations made upon the route of one that occurred within five miles of my residence in the year 1885.

As it seemed to be peculiar in some of its features, I will narrate them as nearly as possible from memory.

It was on a warm day in August; the atmosphere was damp and murky, and an easterly storm of some vigor had prevailed for two days and had not yet cleared off, but the winds had become variable, and I suspect had gotten well to the south, but of this am not certain.

At about 5:30 P. M., a funnel-shaped cloud was seen advancing from the west in a line a little north of east, it was descending a sloping piece of ground which laid on the south side of a narrow valley running about due east or south of east. Before arriving at the bottom of the valley, it passed through a small piece of timber, the main portion of which laid to the south of its track and on rising ground, here the tornado swerved a little towards the south and the main body of timber, as though drawn in that direction. Some large trees were uprooted and others twisted off. On reaching the bottom of the valley the cone-shaped cloud was directly opposite a sharp hill on the north side of the same, and about three hundred yards away.

On the brow of this hill was the house and barn of Mr. Wm. Pritchett, who was standing there observing the storm closely, supposing that the tornado cloud would continue its almost straight course on down the valley, but in this he was deceived. It seemed to stop suddenly in its course, when on coming out of the timber it turned at almost a right angle to its former course and came directly towards the hill upon which he was standing, striking the barn which stood some three hundred feet east of

the dwelling. Mr. Pritchett standing between house and barn was lifted from the ground and carried some thirty or forty feet and thrown against the fence near the house. The barn was badly wrecked, nearly all of the upper timbers with much of the hay, straw, and grain in the sheaf carried away. Shade trees in the yard were prostrated with their tops towards the barn. Out-buildings were unroofed or had their roofs displaced, the old stone mansion being some distance from the center of the tornado withstood the blasts with slight injury.

Mr. Pritchett particularly noticed the color of the cloud as it passed over the wood, being very green by reason of the leaves and branches picked up and of which it was principally composed. Leaving the woods the color changed to that of the soil, until striking the barn it became a light yellow, from the flying wheat straw. After striking the barn the tornado cloud resumed its original course, a little north of east, and still on high grounds, but its violence seemed to have been broken up at the barn, and its further progress could be followed but a few hundred feet with any certainty. What was singular in my opinion in this case, was that a tornado should have formed in the midst of an easterly storm that had prevailed for two days continuously, taking in its general course a direction directly opposite that of the prevailing winds, and its abrupt change of direction in the valley. There can be no doubt as to facts or the nature of this disturbance, as Mr. Pritchett is a well educated gentleman and quite a competent observer.

Although distinctly marked, and leaving undoubted evidence of its tornado character, this storm did not develop the great force we sometimes see on more level grounds. Its course in all could not be traced more than two miles, and I have noted all serious damage done by it. A. SHARPLESS.

THE ANEMOMETER FOR VERTICAL COMPONENTS.

TO THE EDITORS:—In the account of the French meteorological instruments exhibibited at the Paris Exposition which appeared in the November JOURNAL, Mr. Rotch says: "The anemometer of Garrigou-Lagrange giving a diagram of the ver-

tical component of the wind has been perfected by the Richard brothers," thus ignoring the fact that the anemometer is not the invention of M. Garrigou-Lagrange, who only adapted the register which was exhibited by MM. Richard. The anemometer is my invention; it was made by me and operated at Zi-Ka-Wei (China) from 1884 until September, 1887, when I returned to France, the instrument being mounted upon the summit of a light tower at a height of 121 feet above the ground. MM. Richard brothers, recognizing the fact that they were wrong in attributing the whole anemometer to M. Garrigou-Lagrange, promised to modify the placard attached to the anemometer register exposed on the summit of the Eiffel Tower. I also claimed the invention of this anemometer at the International Meteorological Congress in Paris, when I described the results obtained in China, principally those of the year 1886, which were published and distributed to all the observatories. Since my return to France, I have spoken several times before the Academy of Sciences on this subject.

I should be glad to learn that in the United States this new anemometer for the vertical component of tne wind had been tried. It should not be said that special conditions of exposure are necessary for this instrument. I am convinced by experience that the same conditions are needed by the other anemometers for velocity and direction. Unless bad observations are risked, each of these instruments should be entirely isolated and receive the action of the wind as uniformly as possible upon all sides. This is why I advised MM. Richards Brothers to construct a universal anemometer, for which I gave them a design. If it is exposed upon the summit of a light frame tower which but slightly alters the movement of the air, the three elements of direction, horizontal and vertical components of the wind will be obtained under favorable and identical conditions, and consequently the results will merit confidence.

MARC DECHEVRENS, S. J.

ST. HELIER, JERSEY, CHANNEL ISLANDS, January 10, 1890.

[We are glad to publish this abstract and translation of a letter received from Rev. Fr. Dechevrens, establishing his

claim to the invention of the anemometer for vertical currents. As a fulfilment of the wish expressed in the second part of the letter, it may be stated that such an anemometer with the Garrigou-Lagrange register will shortly be in operation at the Blue Hill Observatory. The suggestion of Rev. Fr. Dechevrens for a universal anemometer will certainly commend itself to all who have studied the question of the exposure of anemometers.—A. L. R.]

A SUGGESTION.

TO THE EDITORS:—Can some competent person who has carefully studied the forty year "cycle" theory, which might seem to account for the mildness of the last two winters, kindly embody his work in an article on the subject, for the benefit of one of many interested. INQUIRER.

BOSTON.

CURRENT NOTES.

THE CAUSE OF RAIN.—An extraordinarily reckless theory on this question, by Frank A. Velchow, is printed at full length in *Science* of March 7. It is reckless, because the author writes with no sufficient knowledge of the results of many observers: he takes pains "to show how utterly incapable the existing theories are, ... so as to clear the atmosphere from old cobwebs which might stand in the way of an entirely different view of the whole question." The flippant style of such an essay is clear enough indication of its quality. It explains everything, and no other theory is worth anything. W. M. D.

INDICES FOR THE MISSISSIPPI RIVER.—In the publications of the Corps of Engineers of the U. S. Army, the annual reports of the Chief of Engineers, the reports of the Mississippi River Commission, and in the annual reports of the Coast and Geodetic Survey, is a mass of highly important studies of the Mississippi River, but it is in the midst of so much other matter that it is very difficult to find the information for which one

may be searching. It will interest many of our readers to know that this has now been indexed and made readily accessible. In the annual report of the Chief of Engineers for 1889 on pages 2632–2640 (Part 4) is the index to discharge observations, and on pages 2650–2661 is that for surveys and physical data. There are so many indices scattered through the voluminous government publications, that some one must soon give us an index to the indices.

NUMBER OF THUNDER-STORMS.—M. Rocquigny-Adanson's study of the record of thunder-storms since 1835 at Parc de Baleine (Département de l'Allier, France), shows again, for this case at least, the falsity of the commonly received opinion that thunder-storms are increasing in number. His paper appears in the *Ciel et Terre* where the following average number of days of thunder-storms for this station are given by decades, 1835–1844, 22.3 thunder-storm days per year; 1845–1854. 28.0; 1855–1864, 32.5; 1865–1874, 36.1; 1875–1884, 26.5. The fact appears to be, as stated in Houzeau and Lancaster's Meteorology, that there is a secular variation in the annual number of days of thunder-storms. The minimum was here about 1840, the maximum between 1865 and 1874, while a second minimum is approaching.

A BIOGRAPHICAL SKETCH OF J. C. HOUZEAU has been published by M. A. Lancaster who was closely associated with him in some of his literary undertakings. This sketch is an octavo publication of 120 pages and is very pleasantly written. As we pointed out, at the time of his death, M. Houzeau is an especially interesting personage to Americans as he lived in this country for some time, and engaged actively in the movement for the emancipation of the blacks. He was in Texas at the time of the war and was conscripted. He escaped to Mexico with difficulty and danger, but afterwards came to New Orleans, under Butler's rule of that city, and published an anti-slavery paper there. He afterwards lived in the West Indies for several years. He was a thorough republican, a man of philan-

thropic and amiable character, entirely unyielding when his peculiar views were involved. He was also very active in his scientific and literary pursuits. The list of his writings gives sixty-nine titles of which six were published by himself, and there is given a list of nineteen journals to which he contributed or which he edited. His New Orleans paper was *La Tribune.*

COLD DRY AIR ON CONSUMPTION.—The opinion expressed by Dr. Henry B. Baker of Michigan at the Newport meeting of the American Medical Association that cold dry air is an important factor in the causation of consumption has met with a vigorous protest from Dr. Charles Denison, of Colorado, in the Association's Journal of March 22. Dr. Denison's objections to the theory may be fairly summed up as follows:

(1) The cold dry air to which such important effects are attributed is only such in name, since no account has been taken of relative humidity, absolute humidity alone being considered.

(2) The view taken of the effects of cold dry air upon the body is too exclusive and narrow, for while it exaggerates the importance of its influence within the lungs it fails to take note of the revulsive effects which it undoubtedly has upon the cutaneous surface.

(3) The apparent synchronous relationship between the increased death rate from consumption and the presence of the so-called cold dry air, as shown by Dr. Baker's tables may be explained more satisfactorily as an indirect rather than a direct result, since by driving the inhabitants indoors and subjecting them to ill-ventilation, over-heating and crowding, any tuberculous germs present would be furnished with conditions favorable for their propagation which would not be the case in cold dry air.

And lastly, that the genuine, unadulterated cold dry air which has its natural abiding place along the eastern slopes of the Rocky Mountains from Wyoming to New Mexico, with especial fondness for the region of Denver, does not act upon the pulmonary mucous membrane and its exudate, so as to furnish a

fit soil for the culture of the specific germ of consumption, but that "in chronic infiltration and slight tubercular lung lesions it is believed to be curative by every physician of any ability in this part of the country." W. J. H.

Buys-Ballot.—One by one, with saddening frequency, those whose names are known to meteorologists of all countries are leaving us. On Sunday night, February 2nd, from his well-loved home at Utrecht, passed away the spirit which gave to the world the useful "Buys-Ballot's Law," by which the author will be remembered long after his many personal friends have themselves been removed. Prof. Buys-Ballot was often in this country; he was a corresponding member of the British Association, and attended its meetings, and he was one of the nineteen honorary members of the Royal Meteorological Society. He was 72 years of age, was an Honorary Member of the Society of Arts, of the German and of the Austrian Meteorological Societies, and Knight or Commander of Orders in Austria, Netherlands, Portugal and Prussia.

Besides discharging the duties of his professorship from 1847 to 1887, Dr. Ballot was director, indeed almost creator, of the Royal Meteorological Institute of the Netherlands. In 1883 a new island, discovered by the Dutch Meteorological Expedition, in 70° 25′ 28″ N., was named after him as Buys-Ballot's Island, and in 1887, on giving up his professorial duties, a sort of international banquet was given in his honor, and he was presented with a gold medal specially struck to commemorate the event. Dr. Ballot's earliest scientific papers were upon chemistry and physics, but for forty years nearly all his time and thought has been devoted to meteorology, and his contributions have appeared not only in Dutch, but in German, French, and English.—*Symons's Meteorological Magazine.*

Temperature Observations on the Eiffel Tower.—In a communication to the French Academy of Sciences, December 9, 1889, M. A. Angot gives some interesting details concerning the temperature observations from July to November made on

the summit of the Eiffel Tower, 988 feet above the ground or 1102 feet above sea level. The temperatures are obtained by means of a Richard thermograph, which is controlled by direct observations of the extreme temperatures and by frequent comparisons with a sling thermometer.

The observations are compared with those made at the Park of St. Maur, about ten miles southeast of Paris, at an altitude of 164 feet above the sea. In admitting, as is usual, a decrease of about 1° Fahr. for each 328 feet, the temperature at the summit of the tower should be about 2.86° lower than that of the neighboring country. The difference (St. Maur minus tower), however, is found to be much greater in summer and during the day (difference between mean maxima in July +8.04°) and much smaller in winter and during the night (difference between mean minima in November —3.62°), when there is generally an inversion of temperature and the air is then much warmer at 980 feet elevation than near the ground. The chief cause of these variations is the feeble emissive and absorbing power of the air which is warmed directly very little during the day and cools also but slightly during the night, the diurnal variation of temperature in free air at a certain height being small, but it becomes greater in the lower strata of the atmosphere to which are communicated by contact the temperature changes of the soil. Between 650 and 980 feet the decrease of temperature should be very rapid during the day and very slow at night when inversions are normal during calm and clear weather. These conclusions are completely verified by observations on the tower; on calm and clear nights, especially, the temperature there is frequently nine or ten degrees higher than at the bases.

Other accidental causes may produce differences of temperature still more remarkable. At the time of a change of weather the change sometimes manifests itself at 980 feet elevation several hours or even several days before it occurs at the ground. A striking instance was noted last November. From the 10th to the 24th a period of high pressure reigned in France with calms or very light winds, generally easterly, and low tempera-

ture, especially during the latter days; only on the 24th the wind became strong and changed to the SSW, the temperature rose, the sky became clouded and the bad weather commenced. But on the tower the temperature was still low on the 21st (minimum 28.0°) with a light SE wind, when at 9 P. M. the wind suddenly increased and shifted to the south, then blew steadily from SSW; at the same time the temperature, which was 37.2° at 6 P. M., rose to 43.0° at midnight and to 48.7° at 6 A. M. of the 22nd. From that time it remained high, so that between the evening of the 21st and the morning of the 22nd it was constantly much warmer on top of the tower than on the ground, and at certain times the difference exceeded 18°. The change of weather thus manifested itself at 980 feet altitude more than two days before making itself felt in the lower regions, where the weather was fine, calm and cold, whilst above there was a strong warm wind from the SSW. Observations made with a sling thermometer showed approximately at what height the change took place; thus at 11 A. M. the temperature was 51.0° at 988 feet, 48.4° at 640 feet and 32.2° at 377 feet; between 525 and 590 feet, therefore, was the lower limit of the warm current which was only felt below two days later.

The temperature observations, like those of wind velocity, already discussed, show in an entirely unexpected manner how much the meteorological conditions at an elevation of only 980 feet may differ from those observed near the ground.

THE ATMOSPHERE AND PULMONARY HÆMORRHAGE.—The following views were expressed by Dr. Roland G. Curtin at the Boston meeting of the American Climatological Association as to the effect of atmospheric influences on hæmoptysis:

1. *Preventive and Curative Elements.*—*Rarefied air* arrests the ulceration or other diseased processes and lowers the arterial tension. This greatly overbalances the unfavorable tendency of increased heart action and loss of support to the lungs from diminished air pressure. *Cold air* contracts the tissues and blood-vessels, thus preventing a flow of blood when such tendency exists; its general invigorating effects are beneficial.

Dry air desiccates the pulmonary tissues, decreases the fluidity of the blood, and blocks up the blood-vessels—all favoring the arrest and prevention of bleeding. *Aseptic air* favors repair and cure of lung disease, and kills or dwarfs the action of the disease germ. *Outdoor life*, when not associated with too much exposure, exertion or fatigue, is beneficial.

2. *Causative Elements.—Sea-level air*, by its greater density, diminishes the tendency to hæmoptysis; but the increased arterial tension, and the moisture usually present in such localities, more than counterbalance the beneficial effect of the support given by the air pressure. *Salt air* hastens the breaking down process in tubercular lung disease. The effect is probably good in syphilitic lung troubles and sometimes in simple chronic inflammatory non-tuberculous lung affections. *Moist air* hastens the ulcerative process, liquifies the blood and secretions and renders the tendency to the oozing and flowing of the blood more liable. *Warm air* releases the tissues and blood-vessels, and enervates and relaxes the system at large.

Thus he concludes that each case should be carefully studied in all its phases before deciding on a change of residence. On a high mountain (say from 5,000 to 10,000 feet), a residence far removed from the sea-coast is best for a patient with a tentency to hæmoptysis. At a location of this kind one would probably have not only a rarefied but also a cold, dry, aseptic air; factors which would be most beneficial. Care should be taken that the elevation of the patient should be gradual and not too rapid; otherwise the early effect of a sudden elevation might be followed by unpleasant results. A case of syphilitic phthisis will probably be benefited by sea-air, while a tubercular patient would be injured by it.

THE KANSAS HOT WINDS have received very little discussion, —almost none outside the newspapers of that state. They seem to be southwesterly winds which are so dry and hot as to be often very injurious to crops. Mr. S. B. Jackson, an observer of the Kansas Weather Service says of them:—"Everything on my farm is affected by them. Peanuts, carrots, beets, onions

and sweet potatoes withstand them best. Corn, cane, milo maize, broom and rice corn, millet, castor beans, potatoes, beans, and all kinds of vines are injured more or less. However, but few fields are entirely ruined. There is no crop an entire failure here on account of hot winds, and many farms show no effect of it whatever."

In view of their economic importance we clip the following parts of a discussion of them by Mr. G. H. Allen. These extracts are, like the preceding, from the *Kansas Farmer* and we are indebted for them to Sergeant Jennings of the State Weather Service. Mr. Allen says:—

The cause of these heated currents or waves, is a lack of moisture in the earth and the air above it. They may be prevented by any means which will supply the earth and air with an abundant and constant supply of moisture. The heat of these hot currents of air, called "hot winds," is imparted to them by the reflection of the sun's heat from the hard, dry surface of the earth. The compact nature of the dry, hard prairie sod increases the capillary force of the soil by which its moisture is brought to the surface, whence it escapes by rapid evaporation. When this process has continued until the moisture of the soil is wholly or nearly exhausted, the cooling effect of this evaporation and of the moisture in the earth discontinues, and the heated condition of the air begins and increases with the lapse of time. The sun's heat instead of being dispelled and absorbed is reflected back from the earth's surface and fills the atmosphere, which, fanned into currents by the natural breezes, or made to move by fresh air rushing in to fill the place of that rarified by the heat received, produces the heated waves commonly called hot winds. To establish the truth of this, it is only necessary to state what every person who has experienced the effects of the hot winds knows, that they are never felt during the night, so could not traverse any considerable extent of country. Instead, the heat increases as the sun rises in the sky, being strongest in the middle of the day, and recedes as the sun sinks in the west, ceasing towards night This is the invariable rule, and at those times when the hot winds are the severest, the evenings and nights are the coolest and most pleasant of the season.

So notable are these features of the winds that it is now the general conclusion of the people in the regions affected, that the hot winds are of purely local origin, so far as their heat is concerned.

Mr. Allen thinks the winds could be ameliorated by irrigation, abundant tree-growth and improved cultivation of the soil.

The Influence of Mountains on the Climate of Middle Germany.—Dr. R. Assmann, formerly of the Magdeburg Observatory, now of the Royal Prussian Meteorological Institute

at Berlin, has made a careful study of the influence of mountains on local climatic elements in middle Germany, where a large number of closely placed stations at high and low levels affords good material for discussion. His essay was published in 1886, in the first volume of the *Forschungen zur Deutschen Landes und Volkskunde*, but has only lately come to hand. Among its conclusions, the following may be cited:

North of the Hartz and other mountains, small areas of reduced pressure appear in the annual and seasonal means. These do not suffice to deflect the chief wind-current, but they act on the weaker and less constant winds in such a way that the secondary maxima of wind-frequency are determined by their gradients.

Up and down stream winds by day and night are clearly manifested in the mountain valleys and extend their influence to the neighboring low lands.

The strongest winds near the mountains are those that come from the lower country.

Calms are usually frequent in many valleys and depressions.

In the northern valleys and borders of the chief ranges, distinct foehn-effects are felt in winter.

The influence of the mountains on the mean annual temperature is distinct, especially in narrow valleys and neighboring depressions.

During winter, under high pressure and with an extended sheet of snow on the ground, excessively cold air flows from the mountains and accumulates in the intervening troughs; but this condition is of brief duration and does not lower the mean winter temperature of these regions.

The variations of temperature are greater in the leeward depressions.

Cloudiness is increased on the windward side and strongly decreased to leeward; the increase to windward begins at an appreciable distance away from the foot of the mountains; this influence is strongest in autumn and winter.

Rainfall is strongly increased on the windward side of the ranges, and even at a considerable distance from them; while there is a distinct decrease on the leeward side. This difference is clearly brought out by even the smaller ranges. W. M. D.